United States Patent [19]

Bassett

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[54] **METHODS OF GROUTING OFFSHORE STRUCTURES**

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[73] Assignee: **C. Nelson Shields, Jr., trustee,** Houston, Tex.

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[21] Appl. No.: **351,261**

Related U.S. Application Data

[63] Continuation of Ser. No. 175,184, Aug. 16, 1971, abandoned, which is a continuation-in-part of Ser. No. 858,951, Sept. 18, 1969, Pat. No. 3,601,999.

[52] **U.S. Cl.**..... **61/46,** 61/53.52, 61/53.6, 61/54

[51] **Int. Cl.**..... **E02b 17/00,** E02d 5/24, E02b 17/00

[58] **Field of Search** 61/46, 46.5, 53.6, 53.5, 61/56, 53.52, 56.5, 54

[56] **References Cited**

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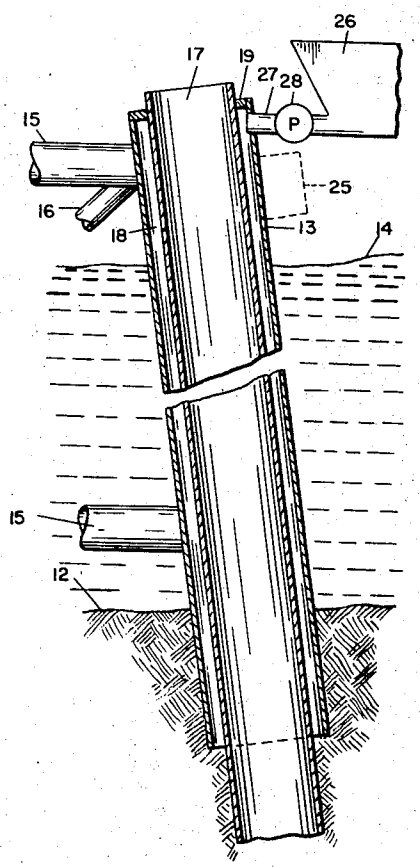
Primary Examiner—Jacob Shapiro

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[57] **ABSTRACT**

A predetermined amount of grouting material is introduced from the top into an annular space between a piling and a jacket of a supporting leg of an offshore structure. The amount of the material is sufficient to displace water from the space through the lower end of the jacket, and when the material sets, it forms a plug in the bottom portion of the annular space. Additional grouting material is then introduced to fill the upper portion of the annular space and is allowed to set.

5 Claims, 4 Drawing Figures



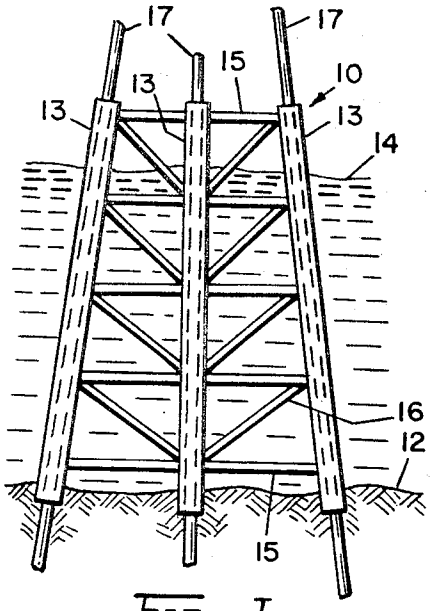


FIG. 1.

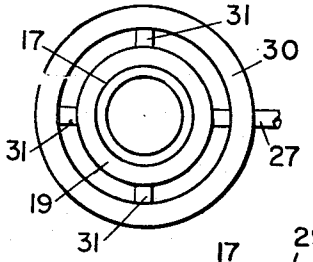


FIG. 4.

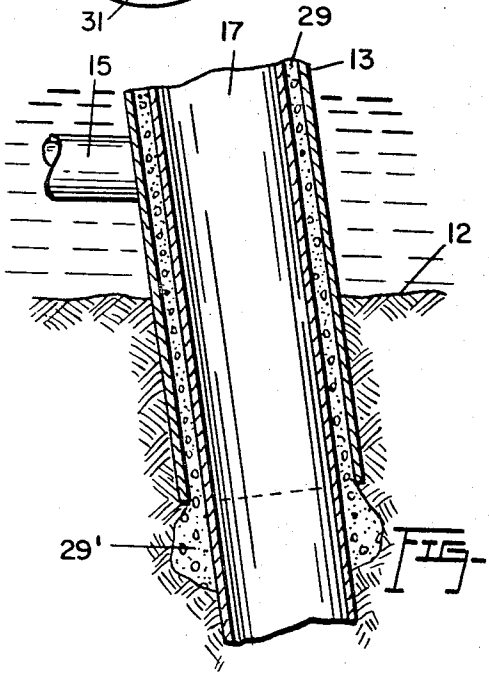


FIG. 3.

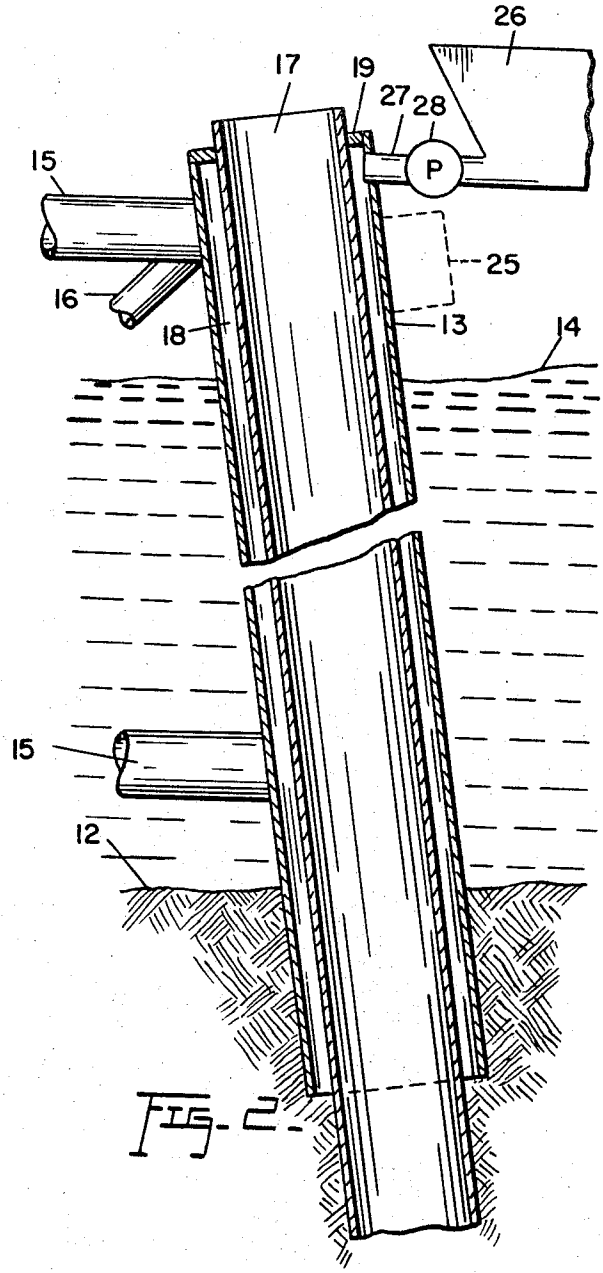


FIG. 2.

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METHODS OF GROUTING OFFSHORE STRUCTURES

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 175,184 filed Aug. 16, 1971 and now abandoned which application in turn is a continuation-in-part of application Ser. No. 858,951 filed Sept. 18, 1969 by Horace W. Olsen and Max Bassett for a Method of Grouting Offshore Structures and now U.S. Pat. No. 3,601,999.

This invention relates to new and useful improvements in methods of grouting offshore structures used in the oil and gas industry. Such structures usually have supporting legs each consisting of a tubular jacket which extends downwardly from above the water line to the sea bed, and a piling which is driven through the jacket into the sea bed. Some clearance necessarily exists, and this results in an annular space between the inside of the jacket and the piling, which space has to be filled with grouting material, particularly in the region of the lower end of the jacket, in order to obtain sufficient rigidity for withstanding tides, ocean currents, and the like.

It has been common in the art for the grouting operation to be performed by divers working at the bottom of the structure on the sea bed, and apart from obvious difficulties inherently associated with working under water, the conventional method often failed to produce fully satisfactory results because water could not be effectively excluded from the space which the grouting material was intended to fill and the grouting material itself became diluted and difficult to set.

The principal object of the invention is to eliminate the above outlined disadvantages of conventional grouting procedures, this being attained by providing an improved grouting method which may be easily and conveniently practiced from above the water line rather than by divers below, and which assures proper placement and setting of the grouting material by exclusion of water therefrom.

As already indicated, this application is a continuation-in-part of copending application Ser. No. 858,951. The grouting method disclosed in that application is also practiced from above the water line, but utilizes compressed air to expel water from the annular space before the grouting material is introduced. In accordance with the present invention, the utilization of compressed air is unnecessary. Rather, the grouting material is introduced in two successive stages, the first being in an amount sufficient to displace water from the annular space and to form a plug in the bottom portion of the space when the material has set. Thereupon, additional grouting material is introduced to fill the upper portion of the space and is allowed to set. At both stages, the grouting material is introduced into the space at the top, that is above the water line, and the necessity of working under water is completely eliminated.

With the foregoing more important object and features in view and such other objects and features which may become apparent as this specification proceeds, the invention will be understood from the following description taken in conjunction with the accompanying drawings, wherein like characters of reference designate like parts and wherein:

FIG. 1 is an elevational view showing a typical installation of an offshore structure on the sea bed;

FIG. 2 is an enlarged, fragmentary vertical sectional view of one of the legs of the structure prior to introduction of grouting material;

FIG. 3 is a fragmentary sectional view, similar to the lower portion of FIG. 2 and showing the grouting material in place; and

FIG. 4 is a top plan view of the leg, showing the grout introducing manifold.

Referring now to the accompanying drawings in detail, the general reference numeral 10 in FIG. 1 designates a typical offshore structure such as is used in the oil and gas industry for offshore drilling, the structure 10 as shown being only the base portion which is installed on the sea bed 12 prior to providing the base portion with the usual deck and other superstructure (not shown). The structure 10 includes a plurality of supporting legs, each in the form of a tubular jacket 13 which extends downwardly from above the water line 14 to the sea bed 12, the several leg jackets being secured together by cross members 15 and diagonals 16 in the conventional manner.

Each leg also includes a tubular piling 17 which is driven through the jacket 13 into the sea bed 12, and inasmuch as some clearance is necessary, an annular space 18 comes into being between the inside of the jacket 13 and the piling 17, as shown in FIG. 2. This annular space must be filled with grouting material, particularly in the region of the lower end of the jacket 13, not only in order to attain leg rigidity sufficient to withstand tides, ocean currents, and the like, but also to protect the piling and the inside of the jacket against corrosion by sea water and air.

After the piling 17 has been driven through the jacket 13 into the sea bed 12, the piling is cut off at the upper end of the jacket and the two components as secured together, as by a weld 19, prior to installation of the deck and other superstructure. The welding operation at 19 in effect constitutes the first step of the method of the invention, in that it seals off or closes the annular space 18 at the upper end of the jacket 13.

The next step of the method involves the introduction of a predetermined amount of grouting material into the annular space 18, as for example from a hopper 26 through a conduit 27 under the action of a pump 28. Significantly, the conduit 27 communicates with the annular space 18 at a point adjacent the upper end of the jacket 13 and above the water line 14 as detailed in FIG. 4, the conduit 27 may be in the nature of a manifold 30, with several branches 31 communicating with the space 18 at circumferentially spaced points, so that the grouting material is introduced evenly around the annular space.

The amount of grouting material introduced at this initial stage is sufficient to form a column with hydrostatic pressure in excess of that of the sea water column on the outside of the leg. This causes the sea water to be displaced from the annular space 18 through the lower end of the jacket 13 by the grouting material 29 itself, thus eliminating the necessity of blowing out the water by compressed air, installing grout lines on the outside of the jacket, or the use of divers to make grouting connections at the sea bed. It is to be understood, of course, that the sea bed 12 is sufficiently porous to facilitate expulsion of water from the space 18 through the lower end of the jacket 13.

Inasmuch as grouting material usually has nearly twice the specific gravity as sea water, it will be understood that the amount of grouting material introduced during this initial stage will fall to the bottom of the annular space **18**, with excess being utilized to displace any contaminated or watery slurry to the outside of the jacket. If the sea bed is soft and muddy, some of the grouting material may flow out of the lower end of the jacket as indicated at **29'** in FIG. **3**.

When a hydrostatic pressure balance is reached, the grouting material will be static and in that condition will reach an initial set, thus forming a plug in the bottom portion of the annular space **18**. The amount of grouting material introduced into the space **18** at this initial stage may be calculated by the following formula:

8.45 weight of sea water/14.8 weight of grout = 57% of the annular space

Thus, a volume of grout material sufficient to fill at least 60 percent of the annular space is initially pumped in and is allowed to fall to a hydrostatic balance point, whereupon the material is permitted to set and form the plug in approximately the bottom half of the annular space.

When the initial grout material plug has set, additional grouting material is introduced through the conduit or manifold **27** to fill the remaining upper portion of the annular space **18**, and when this additional material has set, thr grouting operation is completed.

It will be apparent from the foregoing that the method of the invention performs the grouting operation in two stages; first in introducing a sufficient amount of grouting material to expel sea water from the annular space and allowing this to set to form a plug when a hydrostatic pressure balance is reached; and then introducing additional grouting material to fill the annular space above the plug, and permitting the additional material to set.

Although the invention is primarily concerned with grouting of offshore structures of the general type mentioned, the teachings of the invention are also applicable to grouting of similar structures in general, that is, not necessarily those which rest on the sea bed.

Thus, while in the foregoing there has been described the preferred embodiment of the invention, various modifications and equivalents may be resorted to within the spirit and scope of the invention as claimed.

What is claimed as new is:

1. A method of grouting an offshore structure having at least one supporting leg including a tubular jacket extending downwardly from above the water line to the sea bed and a piling driven through said jacket into the sea bed with an annular space existing between the inside of the jacket and said piling, said method comprising the steps of:

a. sealing the upper end of said jacket to said piling so as to close said annular space at the upper end of the jacket;

b. introducing into said annular space at a plurality of circumferentially spaced points adjacent the upper end of the jacket and above the water line a predetermined amount of grouting material which in relation to the total volume of the annular space is sufficient to form an annular column in the bottom portion of the annular space with hydrostatic pressure in excess of the sea water column on the outside, the sea bed being sufficiently porous so that sea water is displaced from the annular space through the lower end of the jacket by the introduced grouting material itself;

c. allowing the introduced grouting material to set when the hydrostatic pressure is balanced, thus forming a plug in the bottom portion of the annular space;

d. introducing additional grouting material into said annular space at a point adjacent the upper end of the jacket so that the additional grouting material fills the upper portion of the annular space above said plug; and

e. allowing the additional grouting material to set.

2. A method of grouting an offshore structure having at least one supporting leg including a tubular jacket extending downwardly from above the water line to the sea bed and a piling driven through said jacket into the sea bed with an annular space existing between the inside of the jacket and said piling, said method comprising the steps of:

a. sealing the upper end of said jacket to said piling so as to close said annular space at the upper end of the jacket;

b. introducing a predetermined amount of grouting material into said annular space at a point adjacent the upper end of the jacket at a rate sufficient to form an annular column of grout in the upper end of said annular space, the amount of grouting material being sufficient that said annular column has a hydrostatic pressure in excess of the hydrostatic pressure of the sea water column on the outside, the sea bed being sufficiently porous so that sea water is displaced from the annular space through the lower end of the jacket by the downward movement in the annular space of the introduced grouting material itself; and

c. allowing the introduced grouting material to set when it reaches the bottom of the annular space, thus forming a plug in the bottom portion of the annular space.

3. A method as defined by claim **2** and including introducing additional grouting material into said annular space at a point adjacent the upper end of the jacket, allowing the additional grouting material to set.

4. A method as defined by claim **3** wherein the additional grouting material is sufficient to fill the upper portion of the annular space above the plug.

5. A method as defined by claim **2** wherein the grouting material is introduced into said annular space at a plurality of circumferentially spaced points.

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